

Date: 2003-10-06

Engineering Change Order – Class I

MODIFICATION OF THE LQXC CRYO-ASSEMBLY

Brief description of the proposed change(s) :

The position of the magnetic elements in the LQXC ("Q3") inner triplet cryo-assembly is shifted such that the a3-a4-b4 correction elements are placed on the non-IP side of Q3. Related to this change, the MQXA, MQSX and MCBXA magnetic elements are shifted by 300 mm towards the IP, and the relative positions of the interface locations of piping at the non-IP end of the LQXC assembly are shifted by 75 mm to allow more room for the assembly of the beam vacuum interconnect between the LQXC and the DFBX.

Equipment concerned : LQXC MQSXA MCBXA MQXA DFBX	Drawings concerned : LHCLQXA_0162 and related LHCMQSXA0020 and related	Documents concerned : LHC-LQX-ES-0001 LHC-LQX-ES-0008 LHC-LQX-ES-0011 LHC-LQX-ES-0004
PE in charge of the item : Jim Kerby	PE in charge of parent item in PBS : Jim Strait	
Decision of the Project Engineer : <input type="checkbox"/> Rejected. <input type="checkbox"/> Accepted by Project Engineer, no impact on other items. <i>Actions identified by Project Engineer</i> <input checked="" type="checkbox"/> Accepted by Project Engineer, but impact on other items. <i>Comments from other Project Engineers required</i> <i>Final decision & actions by Project Management</i>	Decision of the PLO for Class I changes : <input type="checkbox"/> Not requested. <input type="checkbox"/> Rejected. <input checked="" type="checkbox"/> Accepted by the Project Leader Office. <i>Actions identified by Project Leader Office</i>	
Date of Approval : 2003-10-06	Date of Approval : 2003-10-06	

Actions to be undertaken :

Modify the drawing concerned to reflect the changes described in this ECO.
The cost increase for US-LHC Project is \$144.0k, and has been accepted by the US-LHC Change Control Board on 7 July 2003 in a Baseline Change Request 53.

Date of Completion : 2003-10-06

Visa of QA Officer :

Note : when approved, an **Engineering Change Request** becomes an **Engineering Change Order/Notification**.

1. DETAILED DESCRIPTION

by Jim Kerby

The non-linear correction coil package associated to the Q3 cryo-assembly (LQXC), which contains a3, a4 and b4 layers, must be moved from the IP end to the non-IP end of the assembly. This corrector package was previously part of the MQSXA magnet, but now will be a separate unit mounted by Fermilab to the non-IP end of the MCBXA corrector package that is on the non-IP end of Q3. This requires that the Q3 itself be moved towards the IP to make room between the DFBX and Q3 assembly for the a3-a4-b4 correctors. The IP end-dome of the Q3 cold mass assembly, which encloses the MQSX skew quadrupole corrector, will be unchanged in length, while the non-IP end dome will be extended in length by 225 mm to accommodate the a3-a4-b4 corrector package. The pipes connecting the Q3 to the DFBX will be lengthened by 75 mm to provide additional space for assembling the cold bore interconnect. This results in a shift by 300 mm towards the IP of the magnetic centers of the MQXA, MCBXA and MQSX magnets. The cryostat is also moved 300 mm towards the IP. This increases the distance between the DFBX and the Q3 cryostat, such that a standard 810 mm length vacuum bellows can be used.

The old and new locations of the magnetic elements in the LQXC cryo-assembly are summarized in Table I. The old and new configurations of the LQXC cryo-assembly are shown in Figure 1.

Table I. Longitudinal location changes of magnetic elements in the LQXC cryoassembly.

Component	IP to Mag. Center (old)	IP to Mag. Center (new)	
MQSXA	46.91 m	46.61 m	
MQXA (Q3)	50.45 m	50.15 m	
MCBXA	54.10 m	53.80 m	
b3-b6 correctors	54.30 m	54.00 m	[a]
a3-a4-b4 correctors	46.67 m	~ 54.5 m	[b]

[a] Preliminary longitudinal location of non-linear layers.

[b] Estimated location of a3-a4-b4 layers. Actual location will be determined from detailed mechanical engineering layout.

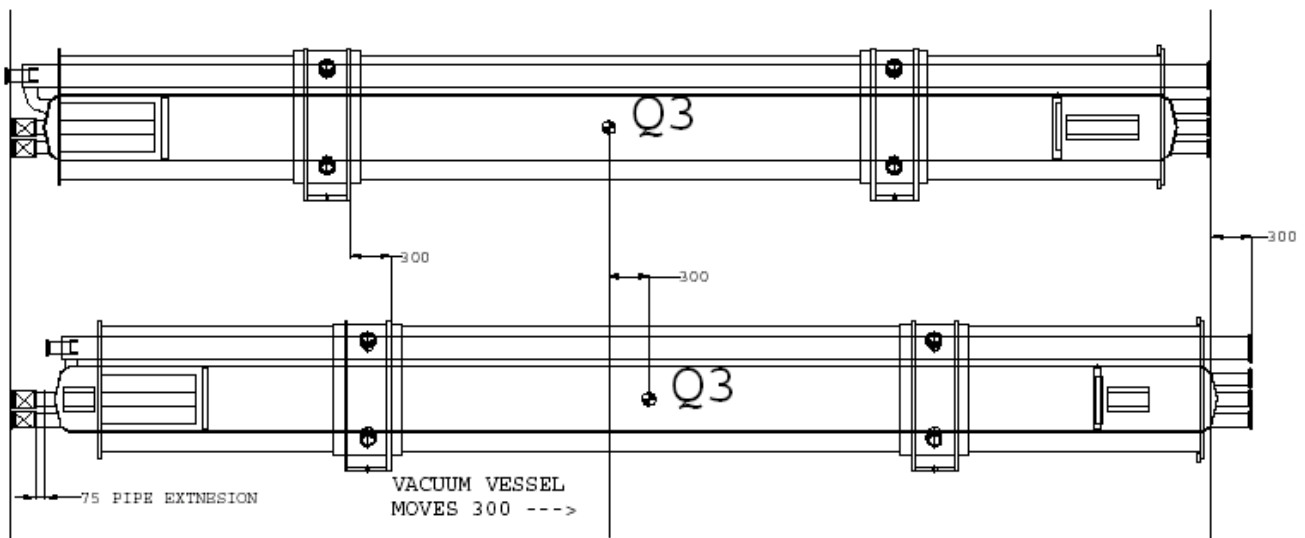


Figure 1. Comparison of the old (top) and new (bottom) configurations of the LQXC cryoassembly.

2. REASONS FOR CHANGE

by Jim Kerby

In the current layout, the a3-a4-b4 corrector package is at a location where the beta functions are equal in the two planes, in which case the scheme for correcting the effect of quadrupole errors on both beams is ineffective. At the new location, the beta functions are substantially different, restoring the effectiveness of the correction system.

Advantage is taken of the necessity to modify the Q3 configuration to provide an additional 75 mm to ease the assembly of the beam vacuum interconnect, and to allow the use of a bellows assembly for the insulating vacuum that is of a standard length used elsewhere in the LHC.

3. IMPACT ON COST, SCHEDULE & PERFORMANCE

by Jim Kerby

The change requires the redesign and rework of the MQSXA magnet and of a number of components required to complete the Q3 cold mass assembly, for the LQXC cryostat assembly, and for the Q2-Q3 interconnect. Changes in the non-IP end interfaces require some parts to be made to adapt the Q3 to the test stand at Fermilab. Table II summarizes the increase of the costs for the LQXC assembly which is the responsibility of the US-LHC project, (i.e. excluding the MQSXA magnet), which occur in three US-LHC Accelerator Project WBS elements.

Table II. Summary of cost increase for Q3 configuration change.

WBS	Description	Labor	M&S	Direct Cost	G&A	Total
1.1.1.3.4	Q1/Q3 Cryostat Parts		\$47,275	\$47,275	\$7,588	\$54,863
1.1.1.6.3	Q1/Q3 Assembly and Test	\$50,550		\$50,550	\$15,342	\$65,892
1.1.1.7.3.3	Q1/Q2/Q3 Cryostat EDIA	\$17,844		\$17,844	\$5,416	\$23,260
	BCR 53 Total	\$68,394	\$47,275	\$115,669	\$28,346	\$144,014

The individual costs of the changes to the LQXC configuration are summarized in Table III, including an estimate of the cost to CERN in each case, for the four options considered. The CERN cost includes \$45k for the MQSXA modification, \$50k for non-standard cryostat vacuum bellows, which are required in two cases, but not in the cases in which the cryostat is shifted by 300 mm. With the shift, standard bellows can be used at no cost, by utilizing available spare units from the running contract. The configuration chosen (last line in Table III) is slightly more expensive than just shifting the correctors, but has the advantages of making no change in the cryostat supports locations on the MQXA, using more standard components and providing additional space in the DFBX-Q3 interconnect.

Table III. Cost increase for individual elements of the Q3 configuration change.

Change	U.S. Cost	CERN Cost	Total Cost
Move correctors	\$63,381	\$95,000	\$158,381
Move correctors + add 75 mm to Q3-DFBX interconn.	\$113,778	\$95,000	\$208,778
Move correctors + shift cryostat 300 mm	\$134,632	\$45,000	\$179,632
Move correctors + both shifts	\$144,014	\$45,000	\$189,014

The cost increase for US-LHC Project is \$144.0k, and has been accepted by the US-LHC Change Control Board on 7 July 2003 in a Baseline Change Request 53. This cost is offset by a reduction of cable testing in the BNL by the same amount. There is no net change in Budget At Completion for the U.S. LHC Accelerator Project as a whole. This ECR therefore concerns only the cost to CERN of an estimated 45 k\$ for the modification of the MQSXA magnet.

The change in configuration of the correction coils will delay the delivery of MQSX and a3-a4-b4 corrector packages, which formerly were to be made as a single unit, by a few months. The time to make the decision about the configuration of the Q3 cryoassembly has forced a postponement of some orders by up to 6 months, and it will take several months to effect the rework of parts already purchased. However, by rearranging the order of production of the different IR quadrupoles and by adding additional cryostat insertion tooling, it will still be possible to minimize the overall production schedule slip and deliver all IR quadrupoles by the dates required by the CERN installation schedule.

4. IMPACT ON OTHER ITEMS

by Jim Kerby

The US-LHC Accelerator Project operates under a set of constraints, including an absolute funding cap, imposed by the US Government. To accommodate the cost of the change in Q3 configuration within the US-Accelerator Project, the duration of the SC cable test program will be shortened by 1.2 months. At the baseline maximum cable testing rate of 200 tests per quarter, the change resulting from this BCR would eliminate approximately 80 cable tests. The actual number of cable tests eliminated depends on the number of samples available for test during this 1.2 month period. This change has been accepted by US-LHC Change Control Board in the BCR 53 and by CERN management (e-mail of Ph. Bryant of 31 July 2003).

The a3-a4-b4 module will now interface to MCBXA magnet. This interface does not require any modifications on the MCBXA assembly, while the a3-a4-b4 module will be mechanically terminated at one end with a flange similar to that used on the previous design of the MQSXA package. Details of the mechanical attachment of the a3-a4-b4 module to the MCBXA package will be completed by Fermilab. Alignment information will be transferred in the same method as is currently done on the MCBX and MQSX assemblies.

The position of the cryostat supports and alignment targets of the Q3 assembly move by 300 mm towards the IP, without any direct implication on the alignment system layout.

5. CHANGE CLASS

by Jim Kerby

Class I.

6. COMMENTS (COMPULSORY)

by Project Engineer

7. COMMENTS (IF REQUIRED)

by other Project Engineers

8. COMMENTS (IF ANY)

by PLO appropriate Committees